

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
4 July 2002 (04.07.2002)

PCT

(10) International Publication Number
WO 02/051802 A1

(51) International Patent Classification⁷: C07C 409/00,
409/38, 409/16, 409/32, 407/00, C08K 5/14, C08F 10/02,
12/08

(21) International Application Number: PCT/EP01/14795

(22) International Filing Date:
14 December 2001 (14.12.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/257,486 22 December 2000 (22.12.2000) US
01200427.1 5 February 2001 (05.02.2001) EP

(71) Applicant: AKZO NOBEL N.V. [NL/NL]; Velperweg 76,
NL-6824 BM Arnhem (NL).

(72) Inventors: WAANDERS, Petrus, Paulus; Bentinckstraat
13, NL-7471 SL Goor (NL). FISCHER, Bart; Bitter-
schoten 42, NL-3831 PC Leusden (NL). ROES, Johannes,
Isidorus; Middenweg 17, NL-7214 EM Epse (NL).

(74) Agent: SCHALKWIJK, Pieter, Cornelis; Akzo Nobel
N.V., Intellectual Property Dept. (Dept. AIP), P.O. Box
9300, NL-6800 SB Arnhem (NL).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,
MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG,
SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN,
YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR,
GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent
(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR,
NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: TRANSPORTABLE AND SAFELY PACKAGED ORGANIC PEROXIDE FORMULATIONS COMPRISING REAC-
TIVE PHLEGMATISERS

(57) Abstract: The invention relates to a method to safely produce, handle and transport packaged organic peroxide formulations comprising a reactive phlegmatizer and to the use of such packaged material in polymerisation and polymer modification processes, particularly the high-pressure (co)polymerisation process of ethylene and/or the suspension (co)polymerisation process of styrene.



WO 02/051802 A1

TRANSPORTABLE AND SAFELY PACKAGED ORGANIC PEROXIDE
FORMULATIONS COMPRISING REACTIVE PHLEGMATISERS

- 5 The invention relates to containers containing specific organic peroxide formulations that can be handled, produced, and shipped in a safe manner and where the organic peroxide formulations contained therein can be used in polymerisation processes where the resulting polymer has a reduced level of undesired residues of low-molecular weight and/or inert phlegmatising agents.

10

Organic peroxides have long been known. Due to the safety hazards associated with most of them, they are often diluted with one or more specific solvents, also known as phlegmatisers. Classical phlegmatising agents are hydrocarbons and esters, such as phthalates.

- 15 US 4,131,728 discloses a polymerisation process employing shock-sensitive peroxides in improved phlegmatisers. The improved phlegmatisers are specific monomers that do not homopolymerise. Exemplified suitable phlegmatising monomers are maleic and citraconic anhydride and esters thereof, fumarates and fumaronitriles, cinnamates and cinnamionitriles, and stilbene.

- 20 US 4,029,875 discloses an ethylene polymerisation process employing a mixture of organic peroxides and cyclic olefins, styrene, or styrene homologues bearing alkyl substituents on the benzene nucleus to reduce the consumption of initiator in the process and to improve the optical and mechanical properties of the polyethylene produced.

- 25 Yu.A. Alexandrov et al. disclose in *Journal of Organometallic Chemistry*, 157 (1978), 267-274, that silicon subgroup organoelement peroxides (peroxides where one Si, Ge or Sn atom is attached to the peroxygen function) in model studies showed specific decomposition behaviour and that the ratio of proton abstraction and addition to double bonds varies depending on the olefin that is
30 used as the solvent. The present invention does not relate to silicon subgroup organoelement peroxides.

In WO 96/03397, disclosing particular safe cyclic ketone formulations, a variety of potential phlegmatisers is mentioned. However, ketone peroxides, including cyclic ketone peroxides, are not the subject of the present invention. It is noted that Akzo Nobel markets formulations of tert. butyl peroxy maleate in
5 dibutyl maleate solvent for specific use in unsaturated polyester resin curing processes with specific curing profiles.

Although many phlegmatisers are known and although reactive compounds have been combined with certain organic peroxides before, there is a need in
10 the industry for packaged peroxide formulations that can be produced, handled, and shipped in a safe manner and where the peroxide formulations, when used in polymerisation reactions, do not lead to the presence of undesired phlegmatising agent in the resin that is produced. The most pressing need is for the supply of peroxides for use in the styrenics and high-
15 pressure ethylene (co)polymerisation industry, where the phlegmatising agent as such should not end up in the final resin. However, such improved formulations which would reduce the amount of low-molecular weight (<1,000 Dalton) products, especially solvents, in the final product could be beneficial also in the process of making acrylic resins, to modify polymers, e.g.
20 polypropylene, and to cure or cross-link polymers, such as polyethylene and unsaturated polyester resins.

In the styrenics industry it is preferred, especially when expandable polystyrene is produced using a suspension polymerisation process, that the
25 phlegmatizer is a-polar in nature to prevent the final resin from becoming more hydrophilic, which interferes with the foaming process. Due to the nature of the polymerisation process, relatively small quantities of concentrated, preferably technically pure, peroxide formulations are used. Traditionally, containers shipped for use in this industry are less than 500 litres, preferably less than
30 250 litres, more preferably less than 30 litres in size. For economic reasons and to reduce the amount of packaging material, the container will preferably contain more than 1 litre, more preferably more than 2 litres, most preferably

more than 10 litres of the (phlegmatised) peroxide, such as the Nourytainers® ex Akzo Nobel. There is a need for a "drop in" replacement for the existing products, so that polymerisation recipes need not be changed, which leads to an improved product (containing less low-molecular weight compounds).

- 5 However, there is also a need for more dilute peroxide formulations, which, for example, could be dosed automatically and/or stored safely in large-size (200 litres, preferably 500 litres or more) storage tanks.

- 10 In the high-pressure ethylene (co)polymerisation process, typically very dilute peroxide formulations, often containing just 10-40%w/w of peroxide and 60-90%w/w of phlegmatizer, are supplied. Particularly in these processes it is highly desirable that most if not all of the phlegmatizer be consumed or reacted, so that the resulting polymer contains an acceptably low amount of phlegmatizer. It is noted that because quite dilute peroxide formulations are to
15 be supplied, it is preferred that the safety characteristics of the formulations are such that the container in which the peroxide formulations are shipped is at least 200 litres, preferably at least 1,000 litres, most preferably more than 10,000 litres in size.

- 20 Furthermore, there is a prejudice against shipping and storing large containers which contain peroxides in combination with reactive compounds for fear of increasing the hazards associated with the handling of said organic peroxides. More particularly, containers containing a peroxide will show a run-away thermal decomposition, also known as a thermal explosion, whenever the heat
25 developing in the container due to decomposition of the peroxide is higher than the heat transmitted to the surroundings. The larger a (practical) container, the lower the surface to volume ratio will be. Therefore, shipment in larger containers is more hazardous. The presence of reactive compounds in peroxide formulations has always been expected to result in a less safe
30 product, because the heat of reaction will contribute to the heat being generated, while the heat transfer to the surroundings is not increased. Hence, the shipment of peroxides dissolved in reactive compounds has never been

commercialised, except for some peroxydicarbonates which have been shipped in monomers with allylic unsaturated groups which do not readily polymerise and must be shipped at very low and impractical temperature of –20°C, or in monomers that do not homopolymerise at all (meaning that no
5 more than 1% of the monomer is converted in a test where a 1:1 weight ratio mixture of monomer and peroxide is kept at 40°C for a period of 100 hours).

Surprisingly, we have found that containers with a size of more than 1 litre and containing organic peroxides and reactive diluents can nevertheless be
10 shipped in a safe fashion at temperatures above –20°C, preferably above –10°C, more preferably above 0°C. The use of the reactive diluent gives the benefit of reduced unbound phlegmatizer in the polymer (so that the polymer contains less volatile product). Particularly in a high-pressure ethylene (co)polymerisation process, the phlegmatizer is consumed without the
15 properties of the polymer being changed and without the polymerisation process being adversely affected. The reduced unbound phlegmatizer levels improve the organoleptic properties of the resulting (co)polymer and may even obviate a vacuum treatment of the molten polymer to reduce volatile material.

20 Accordingly, we claim a method to safely transport specific peroxide formulations comprising reactive phlegmatizers, containers comprising such specific peroxide formulations that are safely transportable, some preferred peroxide formulations that can be transported/shipped in such a fashion, and the use of the preferred peroxide formulations in polymerisation processes,
25 particularly the (co)polymerisation process of ethylene at high pressure to make so-called (modified) low density polyethylene (LDPE) and the suspension polymerisation process to make expandable polystyrene. However, as said, the peroxide formulations according to the invention may be equally desirable in other conventional radical polymerisation, curing, and/or
30 modification processes.

More specifically, we claim a method to safely transport peroxide formulations in containers having a size greater than 1 litre, characterised in that the containers are filled with:

1. from 90 to 1 percent by weight, based on the weight of the content of the container, (%w/w) of one or more peroxides selected from the group consisting of peroxyesters, including peroxyesters of ketone peroxides, peroxycarbonates, including peroxycarbonate derivatives of ketone peroxides, diacylperoxides with from 1 to 48 carbon atoms, diperoxyketals, trioxepans, dialkylperoxides, mixed peroxides, and mixtures of any two or more of these peroxides,
2. from 10 to 99 %w/w of one or more phlegmatisers of which the sole phlegmatiser or, if more than one phlegmatiser is used, the mixture of phlegmatisers has a flash point greater than 5°C and a boiling point that is more than 60°C higher than the self-accelerating decomposition temperature (SADT) of the peroxide formulation, and the phlegmatiser is selected from the group of compounds that react effectively in the polymerisation process.

The flash point is determined in accordance with method ISO 3679 using a Setaflash tester (model 1374 and a sample of 2 ml for flash points up to 110°C and/or a model 1377 and a sample of 4 ml for flash points from 110-300°C).

The boiling point is determined in accordance with EU Council Directive 92/69/EEC of July 31, 1993 (17th adaptation of Council Directive 67/548/EEC) using a Mettler TA-4000 DSC at a temperature scanning rate of 5°C/min using a sample cup with a lid with a pin hole of about 0.5 mm. The experiments were carried out in duplicate. The boiling point is the average of the onset temperatures as determined by intersecting the base line and the extrapolated line touching most of the shoulder of the front of the endotherm peak. Preferably, the boiling point of the reactive phlegmatiser is above 60°C. The SADT is determined a conventional way, using a Differential Scanning Calorimeter (DSC) that is heated at a rate of 2°C per minute. The sample size is about 60 mg, the cups that are used of the type ME HP stainless steel, 270

μl. The SADT is defined to be the temperature that is 50°C below the temperature where the total heat developed is 100W per kg of sample.

Preferably, the containers are more than 200 litres, more preferably more than 5 1,000 litres, most preferably more than 10,000 litres in size. Preferably, they contain 80-2 %w/w of peroxide, more preferably 75-5%w/w, and most preferably 50-10%w/w of peroxide. The higher concentrations (>40%w/w) are preferred when small containers are used (holding less than 200 litres, preferably less than 50 litres, of product), while the lower concentrations 10 (<40%w/w) are preferred when the formulations are shipped in larger containers holding 200 litres or more of the peroxide formulation.

A preferred group of peroxides for shipment in accordance with the present invention are peroxides comprising one or more of the following moieties; 15 peroxyester of the formula $-C(O)OO-$, peroxycarbonate of the formula $-OC(O)OO-$, diacylperoxide of the formula $-C(O)OOC(O)-$, dialkylperoxide of the formula $-OO-$, and trioxepan as disclosed in European Patent Application No.00203888.3, so that peroxides of this group include mixed peroxides (containing any two different peroxygen-bearing moieties in one molecule), 20 and mixtures of any two or more of these peroxides. It is noted that if the peroxides are not liquid at room temperature, they may be soluble in the phlegmatizer or mixture of phlegmatizers. Although the peroxides can be oligomeric or polymeric in nature, it is preferred that they are of the conventional type comprising one, two or three peroxygen bonds in the 25 molecule. Most preferred are (di)peroxyesters, such as 1,1,4,4-tetramethylbutyl-1,4-di(peroxy-2-methylpropanoate), tert-butylperoxy neodecanoate, tert-amylperoxy neodecanoate, 1,1,3,3-tetramethyl butyl-1-peroxy neodecanoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy neodecanoate, tert-butylperoxy pivalate, tert-amylperoxy pivalate, 1,1,3,3-tetramethyl butyl-1-peroxy pivalate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy pivalate, 30 tert-butylperoxy 2-ethylhexanoate, tert-amylperoxy 2-ethylhexanoate, 1,1,3,3-tetramethyl butyl-1-peroxy 2-ethylhexanoate, 1,1-dimethyl-3-hydroxy butyl-1-

peroxy 2-ethylhexanoate, tert-butylperoxy benzoate, tert-amylperoxy benzoate, 1,1,3,3-tetramethyl butyl-1-peroxy benzoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy benzoate, tert-butylperoxy 3,3,5-trimethylhexanoate, tert-amylperoxy 3,3,5-trimethylhexanoate, 1,1,3,3-tetramethyl butyl-1-peroxy 3,3,5-
5 trimethylhexanoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy 3,3,5-trimethylhexanoate, tert-butylperoxy isobutyrate, tert-amylperoxy isobutyrate, 1,1,3,3-tetramethyl butyl-1-peroxy isobutyrate, and 1,1-dimethyl-3-hydroxy butyl-1-peroxy isobutyrate, dialkylperoxides, such as di-tert-butyl peroxide, tert-butyl tert-amyl peroxide, and di-tert-amyl peroxide, and diacyl peroxides, such
10 as bis(3,3,5-trimethylhexanoyl) peroxide. Preferably, the peroxides according to the invention are not shock-sensitive.

The reactive phlegmatizer used in accordance with the present invention must react efficiently in the polymerisation process employing the peroxide
15 formulation. The term "react efficiently" as used herein means that at least 25%, preferably at least 50%, and most preferably more than 75% by weight of the reactive phlegmatizer is reacted in the polymerisation process. In other words, in the most preferred situation, less than 25% by weight of the phlegmatizer used in the process is extractable from the resin (without
20 destruction of the resin). Reaction conditions vary widely; take, for example, the differences between a suspension polymerisation process of styrene, where the bulk of the monomer is typically reacted at temperatures of up to about 100°C at about atmospheric pressure (1 bara), and high-pressure ethylene polymerisation processes, which are conducted at temperatures up to
25 400°C and pressures up to 3,500 bara. The skilled person knows that the reactivity of the phlegmatizer used according to the invention depends on the reaction conditions, such as temperature, pressure, radical concentration, monomer concentration, and the type of monomer. However, whether or not it is a reactive phlegmatizer is easily tested by checking the amount of unreacted
30 phlegmatizer in the polymer. It is to be understood that the term "reactive phlegmatizer" does not relate to conventional phlegmatizers, which do not react and often plasticise the resulting resin.

It is essential that the reactive phlegmatizer fulfil the flash and boiling point requirements. If it does not, then it is less preferred and can it only be used together with one or more other reactive or conventional phlegmatizers such
5 that the mixture does fulfil the flash and boiling point requirements.

It is furthermore to be noted that the reactive phlegmatizers do not encompass regular monomers as used in radical homopolymerization processes, such as styrene and methacrylate. A convenient way to discriminate between
10 suitable reactive phlegmatizers according to the invention and undesired phlegmatizer/solvents, is to determine the SADT of a 50/50 blend, on a weight basis, of a peroxide and a known inert phlegmatizer, such as octane or isododecane, and the SADT of a 50/50 blend of the same peroxide and the
15 reactive phlegmatizer. If the SADT is lowered by 5°C or more, the phlegmatizer is not a reactive phlegmatizer according to the invention. Preferably, the SADT is not lowered at all, or even increased.

Preferred reactive phlegmatizers are α -methyl styrene, (α -methyl) o-methyl styrene, (α -methyl) m-methyl styrene, (α -methyl) p-methyl styrene, stilbene,
20 (cyclic) olefins, unsaturated esters, unsaturated ethers, unsaturated carboxylic acids (and anhydrides thereof), aldehydes, ketones, alcohols, and mixtures thereof. More preferred reactive phlegmatizers are α -methyl styrene, (α -methyl) o-methyl styrene, (α -methyl) m-methyl styrene, (α -methyl) p-methyl styrene, itaconate esters, citraconate esters, (cyclic) olefins, aldehydes,
25 ketones, alcohols, and mixtures thereof. Even more preferred reactive phlegmatizers are α -methyl styrene, (α -methyl) o-methyl styrene, (α -methyl) m-methyl styrene, (α -methyl) p-methyl styrene, (cyclic) olefins, aldehydes, ketones, alcohols, and mixtures thereof. Most preferred is the use of α -methyl styrene and/or (cyclic) olefins.

30

Preferred (cyclic) olefins are selected from the group consisting of cyclopentene, cyclohexene, cycloheptene, cyclooctene, α -pinene, olefins,

such as any isomer selected from the group consisting of hexene, heptene, octene, nonene, decene, undecene, and dodecene, especially α -olefins, such as 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, 1-undecene, and 1-dodecene, and mixtures of any two or more of these (cyclic) olefins. It is noted
5 that the alkenes can be present in any isomeric form, hence they can be linear or branched, and the unsaturated bond can be anywhere in the molecule and both cis and trans configurations are acceptable. Also the olefin can have more than one unsaturated bond in the molecule as in alkadienes (diolefins). If the alkene is branched, the branching preferably is not on the carbon atom
10 attached to a double bond. In other words, the alkene preferably is of the structure $R^1R^2R^3CH=CH-CR^4R^5R^6$ (formula I), wherein each of R^{1-6} represent, independently, hydrogen or a hydrocarbon moiety with preferably up to 12 carbon atoms. More preferably, R is non-aromatic, to prevent environmental problems. The use of 1-alkenes according to formula I is most preferred.

15

The formulations can be produced by blending one or more pure peroxides with one or more of the reactive phlegmatizers. Alternatively, one or more peroxides containing conventional diluents/phlegmatizers can be blended with one or more of the reactive phlegmatizers. Also, it is possible to produce the
20 peroxide in a medium comprising one or more of the reactive phlegmatizers and, optionally, conventional phlegmatizer, such that the packaged end product of the peroxide synthesis step, optionally after one or more other process steps, e.g. a washing step, is a packed peroxide formulation according to the invention. Preferably, the final formulation is essentially free of
25 chlorinated species, since such species may lead to corrosion problems or interfere with the polymerisation process in which the formulations are used as a source of free radicals.

Conventional phlegmatizers include, but are not limited to the group consisting
30 of hydrocarbons, such as (diesel) fuel, paraffinic and white oils, oxygenated hydrocarbons, such as ethers, epoxides, and esters. Examples of preferred conventional phlegmatizers are hydrocarbon solvents, including isododecane,

toluene, xylene, (diesel) fuel, paraffinic oils, and white oils, esters, such as phthalates and adipates, ethers, and epoxides, such as epoxidised soybean oil.

- 5 Preferably, the peroxide formulations according to the invention comprise: 75-1 percent by weight, based on the weight of the formulation, (%w/w) of one or more of the organic peroxides, 25-99 %w/w of one or more reactive phlegmatisers, and 0-50 %w/w of one or more conventional phlegmatisers (that are not α -olefin), up to a total of 100 %w/w.

10

The polymerisation processes for which the peroxide (initiator) formulations according to the invention are pre-eminently suited are of the conventional type, and include processes to make poly vinyl chloride, copolymers of vinyl chloride, poly(meth)acrylate (co)polymers, etc. Preferably, the process is a
15 styrene suspension (co)polymerisation or a high-pressure (co)polymerisation process of ethylene. Comonomers that may be used in the (co)polymerisation process of ethylene are of the conventional type and include alkenes, such as propene, (cyclo)hexene and (cyclo)octene, and vinyl acetate. Comonomers that may be used in the (co)polymerisation process of styrene are of the
20 conventional type and include divinylbenzene. The amount of initiator used in these conventional (co)polymerisation processes will vary, depending on the polymerisation temperature, the capacity for removing the heat of polymerisation, the kind(s) of monomer(s) used, and the applied pressure. Usually, from 0.001-25%w/w of initiator, based on the total weight of the
25 monomers, is employed. Preferably, from 0.001-15%w/w of initiator is employed.

If so desired, the products according to the invention can also be used in the process to modify a (co)polymer, such as in cross-linking, grafting, and
30 controlled degradation processes, e.g. the formation of polypropylene with another molecular weight and/or molecular weight distribution. Also in these processes, the products lead to the formation of less volatile matter in the final

product. Less volatiles can be beneficial in, for instance, the automotive area, where volatiles can lead to fogging of windows.

A most preferred embodiment of the invention is the transport of large
5 containers (≥ 200 litres) containing 75-1%w/w, preferably 50-10%w/w, of one or more organic peroxides selected from the group of tert-butylperoxy neodecanoate, tert-amylperoxy neodecanoate, 1,1,3,3-tetramethyl butyl-1-peroxy neodecanoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy neodecanoate, tert-butylperoxy pivalate, tert-amylperoxy pivalate, 1,1,3,3-tetramethyl butyl-1-peroxy pivalate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy pivalate, tert-butylperoxy 2-ethylhexanoate, tert-amylperoxy 2-ethylhexanoate, 1,1,3,3-tetramethyl butyl-1-peroxy 2-ethylhexanoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy 2-ethylhexanoate, tert-butylperoxy benzoate, tert-amylperoxy benzoate, 1,1,3,3-tetramethyl butyl-1-peroxy benzoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy benzoate, tert-butylperoxy 3,3,5-trimethylhexanoate, tert-amylperoxy 3,3,5-trimethylhexanoate, 1,1,3,3-tetramethyl butyl-1-peroxy 3,3,5-trimethylhexanoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy 3,3,5-trimethylhexanoate, tert-butylperoxy isobutyrate, tert-amylperoxy isobutyrate, 1,1,3,3-tetramethyl butyl-1-peroxy isobutyrate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy isobutyrate, di-tert-butyl peroxide, tert-butyl tert-amyl peroxide, di-tert-amyl peroxide, bis(3,3,5-trimethylhexanoyl) peroxide, 25-99%w/w of one or more reactive phlegmatizers, preferably selected from (cyclo)olefins, most preferably 1-octene, and 0-50%w/w of one or more conventional phlegmatizers, up to a total of 100%w/w.
20 Since the thus transportable peroxide formulations are pre-eminently suited for use in high-pressure ethylene polymerisation processes, a further preferred embodiment of the invention is the method to (co)polymerise ethylene in a conventional high-pressure radical polymerisation process in which peroxides are produced at another site (i.e. off-site), formulated with a reactive
30 phlegmatizer, safely transported to the polymerisation site, and used in the polymerisation process.

Another most preferred embodiment of the invention relates to the transport of containers containing 75-1%w/w of 1,1,4,4-tetramethylbutyl-1,4-di(peroxy-2-methylpropanoate), 25-99%w/w of one or more reactive phlegmatizers, preferably α -methyl styrene, and 0-50%w/w of one or more conventional
5 phlegmatizers, up to a total of 100%w/w.

Since the thus transportable peroxide formulations are pre-eminently suited for use in styrene suspension polymerisation processes, a further preferred embodiment of the invention is the method to (co)polymerise styrene in a conventional suspension polymerisation process in which peroxides are
10 produced at another site (i.e. off-site), formulated with a reactive phlegmatizer, safely transported to the polymerisation site, and used in the polymerisation process.

The invention is elucidated by the following examples.

15

Example 1 and Comparative Example A

In Example 1, tert-butylperoxy 2-ethylhexanoate (Trigonox 21® ex Akzo Nobel) was diluted with 1-octene (ex Acros Organics, product 12944-0000) in a ratio of 1:1 on a weight basis.

20 The experiment was repeated in Comparative Example A using n-octane (ex Haltermann GmbH, No. F122900) instead of 1-octene.

Both formulations have about equal safety characteristics, which is expected to allow their shipment in 1,000-litre containers. More particularly, both
25 formulations have a SADT of 40°C. It is noted that a similar tert-butylperoxy 2-ethylhexanoate dilution with styrene resulted in a formulation that is outside the scope of the present invention with a SADT of 30°C. The use of the formulation of Example 1, compared to the use of the product of Comparative Example A, in a high-pressure (co)polymerisation process is expected to result
30 in a much reduced amount of volatile matter in the resulting (modified) LDPE.

Example 2 and Comparative Example B

1,1,4,4-Tetramethylbutyl-1,4-di(peroxy-2-methylpropanoate) was produced in a conventional manner by reacting 1,1,4,4-tetramethylbutyl-1,4-dihydroperoxide with isobutanoyl chloride. In Example 2 α -methyl styrene was used as a phlegmatizer already during the process, in an amount such that 50% by weight of 1,1,4,4-tetramethylbutyl-1,4-di(peroxy-2-methylpropanoate ($\text{CH}_3\text{CH}(\text{CH}_3)\text{C}(\text{O})\text{OOC}(\text{CH}_3)_2\text{CH}_2\text{CH}_2\text{C}(\text{CH}_3)_2\text{O}-\text{OC}(\text{O})\text{CH}(\text{CH}_3)\text{CH}_3$) in α -methyl styrene was packaged after a conventional optional washing step. In Comparative Example B isododecane was used as the phlegmatizer in the same way.

Both products could safely be produced and transported in containers containing 1 litre or more of the formulation at a temperature of 5°C. In both cases the 1-hour half life (measured in a conventional way with DSC using monochlorobenzene as the solvent) of the peroxide was 87°C. When used in a conventional suspension polymerisation process, the contents of the containers of Example 2 are expected to result in polystyrene beads that are essentially free of extractable phlegmatizer, while the use of the contents of the containers of Comparative Example 2 is known to result in polymers from which virtually all isododecane can be extracted.

Claims

1. A method to safely transport peroxide formulation in containers having a size greater than 1 litre, characterised in that the containers are filled with:
- from 90 to 1%w/w of one or more peroxides selected from the group consisting of peroxyesters, including peroxyester derivatives of ketone peroxides, peroxycarbonates, including peroxycarbonate derivatives of ketone peroxides, diacylperoxides with from 1 to 48 carbon atoms, diperoxyketals, trioxepans, dialkylperoxides, mixed peroxides, and mixtures of any two or more of these peroxides,
 - from 10 to 99%w/w of one or more phlegmatisers with a (joint) flash point greater than 5°C and a (joint) boiling point that is more than 60°C higher than the self-accelerating decomposition temperature of the peroxide formulation, said phlegmatiser being selected from the group of compounds that react effectively in the polymerisation process,
 - 0-75%w/w of optional conventional phlegmatisers, up to a total of 100%,
- with the proviso that it is not a formulation of tert.butyl peroxy maleate with dibutylmaleate.
2. A method to produce a polymer by means of a radical polymerisation process wherein at least 25%w/w of the phlegmatiser that was used to phlegmatise the peroxide or peroxides used as a source of free radicals in said process is reacted such that it is not extractable from the polymer by transporting a peroxide formulation-containing container according to claim 1 to the polymerisation unit and introducing its content into the polymerisation process.
3. The method according to claim 2 wherein the polymerisation process is a high-pressure ethylene (co)polymerisation process.

4. The method according to claim 2 wherein the polymerisation process is a suspension styrene (co)polymerisation process.
5. The method according to claim 3 wherein the reactive phlegmatizer is selected from the group of (cyclic) olefins, aldehydes, ketones, alcohols, and mixtures thereof.
6. The method according to claim 5 wherein the reactive α -olefins are selected from the group consisting of 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, 1-undecen, 1-dodecene, and mixtures thereof.
7. The method according to claim 4 wherein the reactive phlegmatizer is α -methyl styrene.
8. A method according to any one of the preceding claims wherein the peroxide is selected from the group consisting of 1,1,4,4-tetramethylbutyl-1,4-di(peroxy-2-methylpropanoate), tert-butylperoxy neodecanoate, tert-amylperoxy neodecanoate, 1,1,3,3-tetramethyl butyl-1-peroxy neodecanoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy neodecanoate, tert-butylperoxy pivalate, tert-amylperoxy pivalate, 1,1,3,3-tetramethyl butyl-1-peroxy pivalate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy pivalate, tert-butylperoxy 2-ethylhexanoate, tert-amylperoxy 2-ethylhexanoate, 1,1,3,3-tetramethyl butyl-1-peroxy 2-ethylhexanoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy 2-ethylhexanoate, tert-butylperoxy benzoate, tert-amylperoxy benzoate, 1,1,3,3-tetramethyl butyl-1-peroxy benzoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy benzoate, tert-butylperoxy 3,3,5-trimethylhexanoate, tert-amylperoxy 3,3,5-trimethylhexanoate, 1,1,3,3-tetramethyl butyl-1-peroxy 3,3,5-trimethylhexanoate, 1,1-dimethyl-3-hydroxy butyl-1-peroxy 3,3,5-trimethylhexanoate, tert-butylperoxy isobutyrate, tert-amylperoxy isobutyrate, 1,1,3,3-tetramethyl butyl-1-peroxy isobutyrate, and 1,1-dimethyl-3-hydroxy butyl-1-peroxy

isobutyrate, dialkylperoxides, preferably di-tert-butyl peroxide, tert-butyl tert-amyl peroxide, and di-tert-amyl peroxide, and diacylperoxides, preferably bis(3,3,5-trimethylhexanoyl) peroxide.

- 5 9. A polymerization process wherein one or more peroxide formulations that were handled in accordance with any one of claims 1 – 8 is used as a source of free radicals.
- 10 10. A polymer modification process wherein one or more peroxide formulations that were handled in accordance with any one of claims 1 – 8 is used as a source of free radicals.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 01/14795

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07C409/00 C07C409/38 C07C409/16 C07C409/32 C07C407/00
C08K5/14 C08F10/02 C08F12/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07C C08K C08F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 93 25615 A (DOW CHEMICAL CO) 23 December 1993 (1993-12-23) the whole document	1-10
Y	US 4 178 263 A (PRIDDY DUANE B) 11 December 1979 (1979-12-11) the whole document	1-10
Y	US 4 131 728 A (PRIDDY DUANE B) 26 December 1978 (1978-12-26) cited in the application the whole document	1-10
Y	US 5 808 110 A (HOGT ANDREAS HERMAN ET AL) 15 September 1998 (1998-09-15) cited in the application column 4, line 37 - line 47; claims	1-10
	-/-	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *Z* document member of the same patent family

Date of the actual completion of the international search

5 April 2002

Date of mailing of the international search report

29/04/2002

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Bonnevalle, E.

INTERNATIONAL SEARCH REPORT

Int_l onal Application No
PCT/EP 01/14795

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 029 875 A (GLORIOD PIERRE ET AL) 14 June 1977 (1977-06-14) cited in the application the whole document -----	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 01/14795

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9325615	A	23-12-1993	AU 666094 B2 AU 4397793 A CA 2134967 A1 EP 0644916 A1 JP 7507797 T US 5347055 A WO 9325615 A1	25-01-1996 04-01-1994 23-12-1993 29-03-1995 31-08-1995 13-09-1994 23-12-1993
US 4178263	A	11-12-1979	US 4131728 A	26-12-1978
US 4131728	A	26-12-1978	US 4178263 A	11-12-1979
US 5808110	A	15-09-1998	AT 176910 T AU 686466 B2 AU 3643795 A BR 9508409 A CA 2195537 A1 CN 1153514 A ,B CZ 9700184 A3 DE 69507956 D1 DE 69507956 T2 WO 9603397 A1 EP 0772609 A1 HU 77800 A2 JP 10503229 T PL 318322 A1 RU 2154649 C2 TW 414709 B	15-03-1999 05-02-1998 22-02-1996 23-12-1997 08-02-1996 02-07-1997 16-07-1997 01-04-1999 09-09-1999 08-02-1996 14-05-1997 28-08-1998 24-03-1998 09-06-1997 20-08-2000 11-12-2000
US 4029875	A	14-06-1977	FR 2308645 A1 BE 840965 A1 BR 7602468 A CS 191301 B2 DE 2616777 A1 DK 179476 A GB 1504245 A IE 43093 B1 IT 1070212 B JP 1280524 C JP 51135988 A JP 60003085 B LU 74793 A1 NL 7604215 A PT 65008 A ,B SU 667146 A3	19-11-1976 16-08-1976 19-10-1976 29-06-1979 11-11-1976 23-10-1976 15-03-1978 17-12-1980 29-03-1985 13-09-1985 25-11-1976 25-01-1985 12-01-1977 26-10-1976 01-05-1976 05-06-1979